ANALYSIS THE EFFECT OF DIFFERENT TYPE VALVE USE AT DIFFERENT PRESSURE IN PIPING SYSTEM

MUZAKKIR BIN SHUKRI

Thesis submitted in fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Automotive Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

6 DECEMBER 2010

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature
Name of Supervisor: MIMINORAZEANSUHAILA BINTI LOMAN
Position: LECTURER
Date: 6 DECEMBER 2010

STUDENT’S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature
Name: MUZAKKIR BIN SHUKRI
ID Number: MA07077
Date: 6 DECEMBER 2010

ACKNOWLEDGEMENT

I would like to express my highest gratitude to Allah the Almighty for blessing me in finishing this project. Besides, I would like to take this opportunity to express my sincere gratitude and appreciation especially to my supervisor, Madam Miminorazeansuhaila Binti Loman for her constant guidance, consideration and constructive idea in leading me to accomplish this project.

Beside that, I wish to express my sincere appreciation to JP’s and PJP’s in Mechanical Engineering Laboratory, whom I owe particular debt of gratitude for their suggestions, endless effort in helping finding solution and experiences thet has supported me and assisted me tremendously in many aspects.

Last but not least, an expression of thanks is extended to everyone who has offered their help and support especially to my family and friends. All of their helps are very significant to the success of this project. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goal.

ABSTRACT

This project was carried out as a study of flow rate using a single channel acoustic emission (AE) technique. The objective of this project is to study the effect of ball valve, brass gate valve and brass stop cock valve to flow rate using AE technique. A test rig consists of the circumferential galvanized steel pipe, ball valve, gate valve and stop cock valve to run the experiments. The fluid used was water throughout the experiments. The pressure of water was controlled by a valve. The source of AE signal was from the valve and it was captured using AE sensor with the help of Acoustic Emission Detector 2.1.3 software. For all valve conditions, the value of hits, count and RMS (average, maximum and minimum) were recorded and analyzed. All the value recorded were compared among the ball valve, gate valve and stop cock valve. The results were gained from 10 marked points each for all type of valve. The result showed that there was no AE activity on the pipe without valve, the AE activities are greater for high pressure or full close valve. In addition from the RMS against distance graft, RMS value increased when pressure is increased. From the flow rate against RMS graf show that flow rate will decrease when RMS is increased.

ABSTRAK

Projek ini dijalan kan sebagai satu kajian tentang kesan kelajuan dengan menggunakan teknik pancaran akustik (AE) satu siaran. Objektif projek ini adalah untuk mengkaji kesan kelajuan bendalir terhadap penggunaan injap yang berbeza dengan menggunakan teknik AE. Satu rig ujikaji terdiri daripada paip besi galvani berlilitan bulat untuk menjalankan eksperimen ini. Bendalir yang digunakan sepanjang eksperimen ini ialah air. Aliran air dikawal oleh injap. Sumber isyarat AE adalah dari injap itu sendiri dan ianya dicerap dengan menggunakan penderia AE dengan bantuan paparan dari perisian Acoustic Emission Detector 2.1.3. untuk semua keadaan injap, nilai-nilai ‘hits’, ‘counts’ dan RMS (purata,maksimum dan minimum) telah direkod dan dianalisis. Semua nilai yang direkod telah dibandingkan antara injap. Keputusan diperoleh daripada 10 titik yang ditanda pada batang paip. Keputusan menunjukkan bahawa tiada aktiviti AE berlaku pada paip tanpa injap manakala aktiviti AE adalah tinggi untuk paip yang mempunyai injap dan bertutup penuh. Tambahan daripada graf RMS melawan jarak menemui bahawa nilai RMS akan meningkat apabila tekanan meningkat dan daripada graf RMS melawan kelajuan bendalir mendapati nilai kelajuan bendalir akan menurun apabila nilai RMS meningkat.

TABLE OF CONTENTS

		Page
SUPERVISOR'S DECLARATION		ii
STUDENT'S DECLARATION		iii
ACKNOWLEDGEMENTS		iv
ABSTRACT		v
ABSTRAK		vi
TABLE OF CONTENTS		vii
LIST OF TABLES		viii
LIST OF FIGURES		ix
LIST OF SYMBOLS		x
LIST OF ABBREVIATIONS		xi
CHAPTER 1	**INTRODUCTION**	
1.1	Introduction	1
1.2	Objective	3
1.3	Scope of study	3
1.4	Project background	4
CHAPTER 2	**LITERATURE REVIEW**	
2.1	Introduction	5
2.2	Valve	5
2.3	Valve flow characteristic	11
2.4	Valve flow resistance	13
2.5	Flow analysis in a circular pipe	16
2.6	Laminar flow	17
2.7	Turbulent flow	18
2.8	Acoustic emission (AE) signal	21

	2.8.1 Detection of AE	22
	2.82 Processing of AE signal	22
	2.8.3 Displaying AE signal	23
	2.8.4 Locating AE signal	23
CHAPTER 3	**METHODOLOGY**	
3.1	Introduction	25
3.2	Flow chart methodology	25
	3.2.1 Flow chart 1	26
	3.2.2 Flow chart 2	27
3.3	Gantt chart	29
3.4	Test rig and tools preparation	31
3.5	Test procedure	34
3.6	Basic component of piping system	35
CHAPTER 4	**RESULTS AND ANALYSIS**	
4.1	Introduction	38
4.2	Experiment 1	39
4.3	Experiment 2	40
	4.3.1 Fluid flow through ball valve	41
	4.3.2 Fluid flow gate valve	44
	4.3.3 Fluid flow stop cock valve	47
4.4	Summary of average AE parameter value	51
4.5	Reynolds number for high and low flow rate	53
4.6	Determining the location of AE source	54
4.7	Fluid flow through valve	55
4.8	Valve effect classifying	55

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1	Conclusion	58
5.2	Suggestion	58

REFERENCES		60
APPENDICES		62
A	Gantt chart for FYP 1 and FYP 2	62
B	Mode Setup Applied For Acoustic Emission Detector 2.1.3 software	63
C	The example of the test data gain for every pipe conditions	64
D	The example of test data gain	66

LIST OF TABLES

Table No.	Title	Page
2.1	Example of valves and its functions	6
2.2	Resistance coefficient K	15
2.3	Equivalent feet of pipe	15
2.4	Flow coefficient C_v	15
4.1	Result from the measurement process	39
4.2	Average values of AE parameters for steel type of valve	51
4.3	Average values of AE parameters for PVC type of valve	52
4.4	Flow rate for each steel valve condition	54
5.1	Reynolds number values between ball and gate valve	56
5.2	Reynolds number values between ball and stop cock valve	56

LIST OF FIGURES

Figure No.	Title	Page
2.1	Ball valve	6
2.2	Stop cock valve	9
2.3	Gate valve	11
2.4	Valve flow characteristic curve	12
2.5	Laminar boundary layer	18
2.6	Turbulent flow inside pipe	19
2.7	Development of boundary-layer flow in pipe	20
2.8	Detection of AE	22
2.9	Processing of AE signals	22
2.10	Displaying AE signals	23
2.11	Locating AE signals	23
3.1	Pressure gauge	31
3.2	Suitable locations for sensor placement for ball valve classifying test	32
3.3	Hydraulic bench	33
3.4	Acoustic sensor	33
3.5	AED-2000V Virtual Instrument	34
3.6	Ball valve	35
3.7	Gate valve	36
3.8	Hydraulic pump	36
3.9	Hydraulic bench	37
4.1	Result for *counts*	39
4.2	Result for *hits*	40

4.3	Average RMS amplitude for steel ball valve (25psi)	41
4.4	Average RMS amplitude for steel ball valve (20psi)	41
4.5	Average RMS amplitude for steel ball valve (11psi)	42
4.6	Average RMS amplitude for PVC ball valve (25psi)	43
4.7	Average RMS amplitude for PVC ball valve (20psi)	43
4.8	Average RMS amplitude for PVC ball valve (11psi)	44
4.9	Average RMS amplitude for steel gate valve (25psi)	44
4.10	Average RMS amplitude for steel gate valve (20psi)	45
4.11	Average RMS amplitude for steel gate valve (11psi)	45
4.12	Average RMS amplitude for PVC gate valve (25psi)	46
4.13	Average RMS amplitude for PVC gate valve (20psi)	46
4.14	Average RMS amplitude for PVC gate valve (11psi)	47
4.15	Average RMS amplitude for steel stop cock valve (25psi)	48
4.16	Average RMS amplitude for steel stop cock valve (20psi)	48
4.17	Average RMS amplitude for steel stop cock valve (11psi)	49
4.18	Average RMS amplitude for PVC stop cock valve (25psi)	49
4.19	Average RMS amplitude for PVC stop cock valve (20psi)	50
4.20	Average RMS amplitude for PVC stop cock valve (11psi)	50
4.21	Comparison for flow rate value between steel valve	52
4.22	Comparison for flow rate value between steel valve	53
5.1	New AE rig proposed	59

LIST OF SYMBOLS

A	Area
C_v	Flow coefficient
d	Pipe diameter
D	Diameter
K	Resistance coefficient
l_e	Entry length
ρ	Density
Q	Flow rate
R_e	Reynolds number
μ	Fluid Viscosity
V	Flow velocity

LIST OF abbreviations

AE	Acoustic emission
A/D	Analog to digital
D/A	Digital to analog
NDE	Non destructive evaluation
NDT	Non destructive testing
PC	Personal computer
RMS	Root mean square
TFE	Teflon

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The use of pipelines has a long history. For instant, more than 1000 years ago, the Romans use lead pipes in their aqueduct system to supply water to Rome. As the early as 400 B.C., the Chinese use bamboo pipes wrapped with waxed cloth to transport natural gas to their capital Beijing for lighting. Clay pipes were use as early 400 B.C for drainage purpose in Egypt and certain other countries (Henry Liu, 2003).

An important improvement of pipeline technology occurred in the 18th century when cast-iron pipes were manufacturer for use as water lines, sewers, and gas pipelines (Henry Liu, 2003). A subsequent major event was the introduction of steel pipes in the 19th century, which greatly increase the strength of pipes of all sizes. In 1979, the following the discovery of oil in Pennsylvania, the first long distance oil pipelines was build in this state. It was a 6-inch-diameter, 109-mi-long steel pipeline. Nine years latter, an 87-mi-long, 8-inch-diameter pipeline was build to transport natural gas from Kane, Pennsylvania to Buffalo, New York. The development of electric arc welding to join pipes in the late 1920s made it possible to construct leak proof, high-pressure, large-diameter pipelines. Today, virtually all high pressure piping consists of steel pipe with welded joints. Large seamless steel pipe was another major milestone achieved in the 1920s (Henry Liu, 2003).

Major innovations in pipeline technology made since 1950 include:

(i) Introduction of new pipeline material such as ductile iron and large-diameter concrete pressure pipe for water, PVC (polyvinyl chloride) pipe for sewers.
(ii) Use of pigs to clean the interior of pipelines and perform other functions.
(iii) Batching of different petroleum product in a common pipeline.
(iv) Application of cathodic protection to reduce corrosion and extend pipeline life.
(v) Use of large side booms to lay pipe, machines to drill or bore under river and road for crossing, machine to bend large pipes in the field, x-ray to detect welding flaws, and so forth.

Since 1970, major strides have been made in a new pipeline technology including trenchless construction, pipeline integrity monitoring, computer to control and operate pipelines, microwave stations and satellite to communicate between headquarters and room station, and new technologies to transport solid over long distance (e.g., slurry pipelines for transporting coal and other mineral).

Piping system is developed early since a few centuries back. No wonder the development and research will keep running to improve the system time to time. One of the current researches is towards the improvement of monitoring system for the condition of piping line and valves. There are a lot of methods that offer the good way in monitoring the pipe and valve condition such as simulation, radiographic (X-Ray), vibration method, ultrasonic test, and heat distribution test. Currently, many organizations are focused on the non-destructive test (NDT) method which is relatively low cost and time saving especially where the inspected areas are difficult and costly to be accessed.

In this project, the acoustic emission (AE) technique was used to monitor the effect of different flow rate in piping system. The technique is one of the NDT group and the application is still new in term of monitoring the flow rate and internal surface pipe condition. It is well known that this technique is widely used for geological, material behaviour and structure monitoring especially in term of crack investigation

(Hafizi, 2008). This technique was developed base on the theory of transient elastic wave that emit from rapid strain energy release inside a material that is subjected to stress. The energy is come from the changes of flaws that occur inside the material. This technique offers cost and time saving because the monitoring activity will be done without breaking any parts and also can be done online (without stopping the operation). The sensors will be located at any component and will sense the transient elastic wave known as AE signal that will further analyzed to indicate the component's condition. Although current most popular NDT method is ultrasonic testing method, the AE technique give us the alternative approach of flow rate detection and monitoring in piping systems.

1.2 OBJECTIVES

For this project, two main objectives are listed:

(i) To measure the Acoustic Emission (AE) signal in pipe line without valve.

(ii) To find the effect of flow rate by using ball valve, gate valve and stop cock valve with three different pressures.

1.3 SCOPE OF THE STUDY

For this case study, the acoustic emission technique will be used to monitor the pipe and flow condition. One pipe is used with different type of valve: ball valve, brass gate valve and stop cock valve. Practically valve is use to control the flow in the piping system. Data from the acoustic signal were then analyzed to get the acoustic characteristic in term of time domain. For this project, three tests or experiments were conducted in order to achieve the objectives. The first test was to show the effect using low flow rate with different type of valve and the procedures were the same for another two experiments except the pressure are different. In this project, we will use acoustic emission technique where the sensor will be located ten point along the pipe line. All AE parameters observed were time domain; peak amplitude, RMS and energy. Then the analysis will be done using all the data taken using acoustic emission technique.

1.4 PROJECT BACKGROUND

Piping system is one of the technologies that help to provide the quality of human life. It offers the basic need for humankind such as for washing, petrol station and cooking. Besides, piping system also important in the transportation of ‘precious’ fluid such as petroleum and natural gases. For this commercial purpose, pressure drop is vital to be avoided since it give relatively big loses to the annual profit. The lost can be the result of leakage, different flow rate and many other possible causes. The study of this project is to analyze the effect of different pressure at different type of valve use in piping system so that all the vital propose can be avoided.

1.5 DISSERTATION ORGANISATION

There are several chapters in this dissertation. The chapters are organized well to assure the well understanding for readers. The organization is as below:

Chapter 1	:	Introduction
Chapter 2	:	Literature Review
Chapter 3	:	Methodology
Chapter 4	:	Result and Analysis
Chapter 5	:	Conclusion and Recommendations

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will briefly explain about basic piping system, valves, flow analysis in a circular pipe, turbulent behaviors, acoustic emission (AE) signals, the different between AE and ultrasonic testing method and a few related studies and journals that have been done by current researchers. Besides, the information about the software that will be used also included here. All this information is important before furthering to the analysis and study later.

2.2 VALVES

Due to the various environments, system fluids, and system conditions in which flow must be controlled, a large number of valve designs have been developed. A basic understanding of the differences between the various types of valves, and how these differences affect valve function, will help ensure the proper application of each valve type during design and the proper use of each valve type during operation. Table 2.1 shows the example of valve type and its function.

Table 2.1: Example of valves and its functions

TYPE	FUNCTION
Ball valve	To control open/close
Butterfly valve	To control flow in a big diameter pipe
One way valve	Control flow to move only in one direction
Needle valve	To release high pressure flow slowly

Basically, valve is used to control the flow in a piping system. It can be operated either using manual or automatic control. Valves come with variety of sizes and also in wide range of prices. It can be used as simple as to control open and close the flow of a system. It also can very complex and specific as can be seen in many power plants. The valve that used in this study is ball valve (figure 2.2), stop cock valve (figure 2.3) and gate valve (figure 2.4).

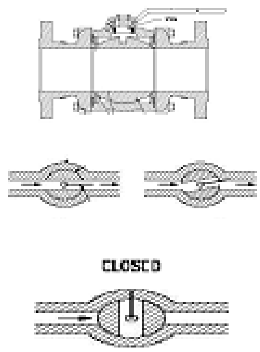

Figure 2.1: Ball valve

Source: http://www.tpub.com

The advantages of ball valve are generally the least expensive of any valve configuration and has low maintenance costs. In addition to quick, quarter turn on-off operation, ball valves are compact, require no lubrication, and give tight sealing with low torque. But the disadvantages is conventional ball valves have relatively poor throttling characteristics. In a throttling position, the partially exposed seat rapidly erodes because of the impingement of high velocity flow (Stephen, 2008).

Ball valves are available in the venture, reduced and full port pattern. The full port pattern has a ball with a bore equal to the inside diameter of the pipe.

Balls are usually metallic in metallic bodies with trim (seats) produced from elastomeric (elastic materials resembling rubber) materials. Plastic construction is also available. The resilient seats for ball valves are made from various elastomeric materials. The most common seat materials are Teflon (TFE), filled TFE, Nylon, Buna-N, Neoprene, and combinations of these materials. Because of the elastomeric materials, these valves cannot be used at elevated temperatures. Care must be used in the selection of the seat material to ensure that it is compatible with the materials being handled by the valve.

The stem in a ball valve is not fastened to the ball. It normally has a rectangular portion at the ball end which fits into a slot cut into the ball. The enlargement permits rotation of the ball as the stem is turned.

A bonnet cap fastens to the body, which holds the stem assembly and ball in place. Adjustment of the bonnet cap permits compression of the packing, which supplies the stem seal. Packing for ball valve stems is usually in the configuration of die-formed packing rings normally of TFE, TFE-filled, or TFE-impregnated material. Some ball valve stems are sealed by means of O-rings rather than packing.

Some ball valves are equipped with stops that permit only 90° rotation. Others do not have stops and may be rotated 360°. With or without stops, a 90° rotation is all that is required for closing or opening a ball valve. The handle indicates valve ball position. When the handle lies along the axis of the valve, the valve is open. When the handle lies 90° across the axis of the valve, the valve is closed. Some ball valve stems have a groove cut in the top face of the stem that shows the flow path through the ball. Observation of the groove position indicates the position of the port through the ball. This feature is particularly advantageous on multiport ball valves (Stephen, 2008).

A butterfly valve is a valve which can be used for isolating or regulating flow. The closing mechanism takes the form of a disk. Operation is similar to that of a ball valve, which allows for quick shut off. Butterfly valves are generally favored because they are lower in cost to other valve designs as well as being lighter in weight, meaning less support is required. The disc is positioned in the center of the pipe, passing through the disc is a rod connected to an actuator on the outside of the valve. Rotating the actuator turns the disc either parallel or perpendicular to the flow. Unlike a ball valve, the disc is always present within the flow, therefore a pressure drop is always induced in the flow, regardless of valve position.

A butterfly valve is from a family of valves called quarter-turn valves. The "butterfly" is a metal disc mounted on a rod. When the valve is closed, the disc is turned so that it completely blocks off the passageway. When the valve is fully open, the disc is rotated a quarter turn so that it allows an almost unrestricted passage of the fluid. The valve may also be opened incrementally to throttle flow.

There are different kinds of butterfly valves, each adapted for different pressures and different usage. The resilient butterfly valve, which uses the flexibility of rubber, has the lowest pressure rating. The high performance butterfly valve, used in slightly higher-pressure systems, features a slight offset in the way the disc is positioned, which increases the valve's sealing ability and decreases its tendency to wear. The valve best suited for high-pressure systems is the trimetric butterfly valve, which makes use of a metal seat, and is therefore able to withstand a greater amount of pressure.

Butterfly valves are valves with a circular body and a rotary motion disk closure member which is pivotally supported by its stem. A butterfly valve can appear in various styles, including eccentric and high-performance valves. These are normally a type of valve that uses a flat plate to control the flow of water. As well as this, butterfly valves are used on firefighting apparatus and typically are used on larger lines, such as front and rear suction ports and tank to pump lines. A butterfly valve is also a type of flow control device, used to make a fluid start or stop flowing through a section of pipe. The valve is similar in operation to a ball valve. Rotating the handle turns the plate either parallel or perpendicular to the flow of water, shutting off the flow. It is a very well known and well used design. But here are some general rule-of-thumbs. Any valve will work in any application for a certain period of time.

A stopcock is a valve used to restrict or isolate the flow of a liquid or gas through a pipe. In Great Britain a stopcock, not to be confused with a gate valve or a DiCiaccio branch, is used to prevent flow of water into a domestic water system. There are usually two stopcocks for a home. One is usually found just outside the property boundary and can be used to isolate the building from the water supply. The other is inside the property where the supply enters the property. These valves are provided to allow maintenance and prevent flooding if the domestic water system is pierced.

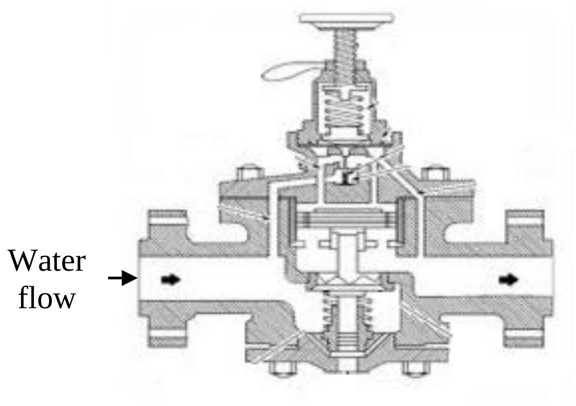

Figure 2.2: Stop cock valve

Source: http://www.tpub.com

A gate valve, also known as a sluice valve, is a valve that opens by lifting a round or rectangular gate/wedge out of the path of the fluid. The distinct feature of a gate valve is the sealing surfaces between the gate and seats are planar, so gate valves are often used when a straight-line flow of fluid and minimum restriction is desired. The gate faces can form a wedge shape or they can be parallel. Typical gate valves should never be used for regulating flow, unless they are specifically designed for that purpose. On opening the gate valve, the flow path is enlarged in a highly nonlinear manner with respect to percent of opening. This means that flow rate does not change evenly with stem travel. Also, a partially open gate disk tends to vibrate from the fluid flow. Most of the flow change occurs near shutoff with a relatively high fluid velocity causing disk and seat wear and eventual leakage if used to regulate flow. Typical gate valves are designed to be fully opened or closed. When fully open, the typical gate valve has no obstruction in the flow path, resulting in very low friction loss.

Gate valves are characterized as having either a rising or a no rising stem. Rising stems provide a visual indication of valve position because the stem is attached to the gate such that the gate and stem rise and lower together as the valve is operated. No rising stem valves may have a pointer threaded onto the upper end of the stem to indicate valve position, since the gate travels up or down the stem on the threads without raising or lowering the stem. No rising stems are used underground or where vertical space is limited.

Bonnets provide leak proof closure for the valve body. Gate valves may have a screw-in, union, or bolted bonnet. Screw-in bonnet is the simplest, offering a durable, pressure-tight seal. Union bonnet is suitable for applications requiring frequent inspection and cleaning. It also gives the body added strength. Bolted bonnet is used for larger valves and higher pressure applications.

Another type of bonnet construction in a gate valve is pressure seal bonnet. This construction is adopted for valves for high pressure service, typically in excess of 15 MPa (2250 psi). The unique feature about the pressure seal bonnet is that the body - bonnet joints seals improves as the internal pressure in the valve increases, compared to other constructions where the increase in internal pressure tends to create leaks in the body-bonnet joint.

Gate valves may have flanged ends which are drilled according to pipeline compatible flange dimensional standards. Gate valves are typically constructed from cast iron, ductile iron, cast carbon steel, gun metal, stainless steel, alloy steels, and forged steels (Stephen, 2008).